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LETTER TO THE EDITOR

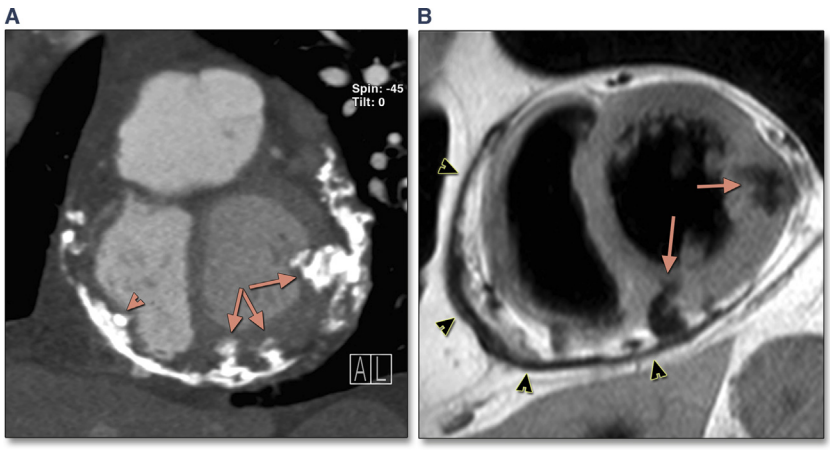
Calcified Constrictive Pericarditis: Prevalence, Distribution Patterns, and Relationship to the Myocardium

Constrictive pericarditis (CP) represents the final stage of chronic inflammation of the pericardium with impediment of cardiac filling. The morphologic hallmark is a stiff fibrotic, not infrequently calcified, pericardium. Computed tomography (CT) is a better imaging modality to depict the presence and to evaluate the extent of calcifications than traditional methods such as chest x-ray or fluoroscopy. The fibrocalcified process, however, may extend into the underlying myocardium as well and CT has a distinct advantage to identify this. In this retrospective study (2005 to 2015), we present our experience of using CT to identify calcific myocardial penetration in a clinical series of 43 patients (36 men, mean 64 ± 11 years of age) with CP, diagnosed at echocardiography (n = 40), cardiac catheterization (n = 29), or during pericardiectomy (n = 28). CT was performed in 41 patients (95%). Cardiac magnetic resonance was available in 33 patients. No underlying cause for CP was found in the majority (n = 24). History of prior cardiac surgery (n = 6), previous thoracic radiotherapy (n = 4), infections (tuberculosis in 5 and non-tuberculosis in 3), and asbestosis (n = 1) were etiologies in the rest.

Pericardial calcifications were present in 28 of 41 patients (68%) on CT, compared to 21 of 43 patients (49%) at conventional chest x-ray and 14 of 29 patients (48%) at cardiac catheterization. The basal part of the ventricles and atrioventricular grooves were most frequently calcified (left ventricle n = 23, right ventricle n = 20), followed by the right ventricular outflow tract (n = 20), and the right atrium (n = 17). Pericardial calcifications were thickest in the basal parts of the ventricles and atrioventricular grooves (right 4.2 ± 2.3 mm, range 1 to 10 mm; left 3.6 ± 2.0 mm, range 1 to 8 mm).

Extension of calcifications into the myocardium was found in 17 of 28 patients (61%): right-sided (n = 6), left-sided (n = 2), and mixed right-left-sided (n = 9). The basal parts of the ventricles (right n = 8, left n = 9) and right ventricular outflow tract (n = 8) were preferentially involved. Deep extension into the inner half of the left ventricular myocardium was present in 7 patients (Figure 1A). The involved

FIGURE 1 Representative Images of Deep Myocardial Penetration of Calcifications at Computed Tomography and CMR



(A) A 61-year-old woman with an idiopathic form of constrictive pericarditis (CP). Presence of massive pericardial calcifications with massive, deep penetration of both left ventricular (LV) **(arrows)** as well as right ventricular wall **(arrowhead)**. **(B)** A 62-year-old man with history of tuberculosis. T1-weighted spin-echo cardiac magnetic resonance (CMR). Irregular thickened pericardium **(black arrowheads)**. The calcifications, appearing hypointense, penetrate deeply the inferior and lateral LV wall **(arrows)**. At cine cardiac magnetic resonance (see Online Video 1), the involved segments are thickened and hypocontractile (lateral wall segment end-diastolic wall thickness 17 mm, systolic wall thickening 6%) and the left ventricle shows a mild systolic dysfunction (LV ejection fraction 53%).

myocardial segments in these patients appeared thickened at cardiac magnetic resonance (i.e., end-diastolic wall thickness 12.2 ± 3.4 mm; hypocontractile systolic wall thickening 14 ± 6%) as compared to patients with no evidence of penetration of calcification into the myocardium (i.e., end-diastolic wall thickness 6.8 ± 1.5 mm, $p = 0.009$; systolic wall thickening 72 ± 26%, $p < 0.0001$) (**Figure 1B**, Online Video 1). Moreover, left ventricular ejection fraction was significantly lower in patients with deep myocardial extension of calcifications, (i.e., 50.7 ± 5.6%) compared to patients without myocardial penetration of calcifications (i.e., 63.4 ± 8.2%; $p = 0.0023$ Mann-Whitney test). Nine patients with myocardial penetration of calcification (53%) underwent pericardiectomy. During cardiac surgery, 3 patients experienced a dissection of cardiac wall (right ventricle n = 2, right atrium n = 1), all 3 had myocardial extension of calcifications. At follow-up 5 patients died, 1 of whom had deep myocardial penetration of calcification.

Pericardial calcifications are a frequent finding on CT in CP. Penetration into the underlying myocardium is not uncommon and in some cases may extend deep toward the subendocardium. If present, such involved segments are thickened as well as hypocontractile and myocardial penetration may influence surgical outcomes.

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APPENDIX For a supplemental video, please see the online version of this article.